REMARKS

In response to the Office Action mailed May 1, 2007, Applicant respectfully requests that the Examiner reconsider the above-captioned patent application in view of the following comments. Claims 1-40 remain pending, of which Claims 8-19 and 35 have been withdrawn from consideration. No claims are amended, added or cancelled in this paper.

The results of the Office Action mailed May 1, 2007 are summarized as follows:

CLAIM NOS.	DISPOSITION/REJECTION		
	BASIS	PRIMARY REFERENCE	SECONDARY REFERENCE(S)
1-4, 20-23, 27-29, 31, 33-37, 39	102(b)	DiMatteo US 6,440,164	n/a
1-4, 28, 37	102(e)	Devellian US 2005/0070952	n/a
5, 29, 30, 33-36, 38	103(a)	Devellian US 2005/0070952	Duran US 5,489,297
5, 24, 30, 38	103(a)	DiMatteo US 6,440,164	Duran US 5,489,297
6, 7, 25, 26, 32, 40	103(a)	DiMatteo US 6,440,164	Soetikno US 2002/0143387

DiMatteo Reference - Claim 1

DiMatteo does not disclose or suggest all of the elements recited in Claim 1. For example, DiMatteo does not teach "bio-absorbable means for blocking blood flow past said stent when implanted in a vein" as recited in Claim 1.

DiMatteo teaches a device with two portions: leaf frames and a non-absorbable cell covering that blocks blood flow in one direction in a lumen. The leaf frames may or may not be formed from a bioabsorbable material, and the fact that some embodiments have both non-absorbable leaf frames and a non-absorbable cell covering shows that bioabsorbability is not a central feature of the DiMatteo reference. DiMatteo at 10:51-54. The leaf frames can have apertures that are "covered with cultured tissue cells." DiMatteo at 10:39-40. The end goal is for these cultured tissue cells to remain in place; the cells grow and eventually "provide the fully functioning valve." DiMatteo at 10:49-50. Instead of being bioabsorbed, these tissue cells are designed to remain and to grow, becoming permanent fixtures. Whether or not the leaf frame portion of the DiMatteo device is formed from bioabsorbable material, in every case the cell

covering portion of the DiMatteo device is designed to function as a permanent, non-absorbed valve.

Claim 1 recites, among other things, a "bio-absorbable means for blocking blood flow... ." The portion of the DiMatteo device that may, in some cases, be absorbed by the body cannot, by itself, block blood flow because the "apertures" in the leaf frame allow blood to flow. Moreover, if an absorbable DiMatteo leaf frame were placed in a body without a cell covering, such a device would eventually degrade and disappear, blocking no blood flow. Accordingly, without the cell covering, the DiMatteo technology would fail in its own purpose of providing a replacement vascular valve. DiMatteo therefore teaches that it is the combination of a leaf frame and a cell covering, not either portion taken alone, that can functions as a valve.

DiMatteo therefore fails to teach a "bio-absorbable means for blocking blood flow...." A device that is only partially absorbable is not "bio-absorbable" as the term is understood in the medical device field. The following excerpts from medical literature[1] (full versions of which are included in the appendix) demonstrate use of the term "bioabsorbable" in the art, in a manner consistent with this understanding:

Supporting Quotation	Source
"Unlike a metallic stent, a bioabsorbable stent is designed to be slowly metabolized by the body and completely absorbed over time."	Abbott Announces Positive Six-Month Results From the World's First, Clinical Trial of a Fully Bioabsorbable Drug-Eluting Coronary Stent, Bio-Medicine, Mar. 24, 2007, http://www.bio-medicine.org/medicine-technology/Abbott-Announces-Positive-Six-Month-Results-From-the-Worlds-First-0AClinical-Trial-of-a-Fully-Bioabsorbable-Drug-Eluting-Coronary-Stent-1182-1/.
"Bioabsorbable plates and screws are completely reabsorbed into the body within 12 to 15 months with no sign of being implanted."	William L. Abernathy et al., Nonmetallic Fixation in Elective Maxillofacial Surgery, 71 AORN J. 193, January 2000, http://findarticles.com/p/articles/mi_m0FSL/is_1_71/ai_59035025.

[1] Although three of these articles are dated after the priority date of the present application, they are nonetheless probative of the manner in which the term "bioabsorbable" was used as of the priority date, and confirm the usage evinced by the Abernathy article of January 2000. There is no reason to believe that the usage of the term changed between the priority date and the dates of the later three articles. The agreement between Abernathy and the other three articles indicates that usage remained the same.

Supporting Quotation	Source
"As with all bioabsorbable implants, they biologically resorb over time, allowing the load to transfer to the bone after primary bone healing and eventually completely disappear through safe biological resorbtion."	Inion Ltd., http://www.inion.com/Products/sportmedicine/en_GB/General_FAQ/ (last visited Oct. 29, 2007).
"[B]ioabsorbable stents, once they are bioabsorbed, leave behind only the healed natural vessel."	Ron Waksman, Adjunctive Therapy: Biodegradable Stents: They Do Their Job and Disappear, 18 J. Invasive Cardiology 70, Feb. 2006, http://www.invasivecardiology.com/article/5222#.

These quotations show that the term "bioabsorbable" is used for medical devices that are fully reabsorbed into the body. Thus, where a portion of a device remains or persists on a permanent basis, such as DiMatteo's tissue cells and some embodiments of DiMatteo's leaf frames, the overall device is not bioabsorbable.

For at least the reasons discussed above, the DiMatteo reference does not disclose or suggest the limitations of Claim 1, including the limitation "bio-absorbable means for blocking blood flow past said stent when implanted in a vein."

DiMatteo Reference - Other Claims

Although they recite combinations of features that differ somewhat from that recited in Claim 1, the other independent claims rejected by the Examiner as anticipated by DiMatteo are patentable for the same reasons provided above with respect to Claim 1. For example, independent Claim 20 recites a "bio-absorbable closure device," and Claims 29 and 37 each recite a "bioabsorbable blocking wall." These limitations are not disclosed or suggested by the DiMatteo reference.

Devellian Reference - Claim 1

Devellian does not disclose or suggest all of the elements recited in Claim 1, which stands rejected as anticipated by Devellian. For example, Claim 1 includes the following language: "means for blocking blood flow past said stent when implanted in a vein." This is not taught by Devellian, and in many respects, Devellian teaches away from this element of Claim 1.

The specified limitation of Claim 1 is introduced with the terms "means for." The corresponding function is "blocking blood flow past said stent when implanted in a vein." In the examination of means plus function claims, the Examiner must show that a given prior element performs a function identical to that specified in the claim. See MPEP § 2184, second paragraph; *In re Donaldson*, 16 F.3d 1189 (Fed. Cir. 1994). Moreover, unless an element performs the identical function specified in the claim, it cannot be an equivalent for the purposes of 35 U.S.C. 112, sixth paragraph. *Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931, 4 USPQ2d 1737 (Fed. Cir. 1987), *cert. denied*, 484 U.S. 961 (1988). See MPEP § 2184 II, first paragraph. Devellian teaches use of the disclosed device only in the left atrial appendage ("LAA"), not a vein. Thus, the Devellian reference does not anticipate Claim 1, either literally or through an equivalence analysis.

Claim 1 is also patentable over Devellian for reasons of non-obviousness. The Devellian LAA insert device is not suited for positioning in a vein, so a person of ordinary skill in the art would not seek to use the Devellian device in that particular anatomy. Because they are specifically designed for positioning in an LAA, the contours of the Devellian device are not appropriate for any part of the venous system.

The conical/tapering shape and proximal flange of the Devellian device make it ill suited for positioning in a vein lumen. If the Devellian device were so positioned, the rim of the flange (and likely no other portion of the device) would abut the vein wall, causing high pressure concentration and possible injury of the vein wall or surrounding tissue in the small abutting rim region. Alternatively, the device would slip and migrate within the vein due to insufficient engagement of the device to the vein wall. Blood flow would also be problematic – if the device tip is pointed "into" the oncoming blood flow, the taper/cone would force the blood flow outward against the vein wall, tending to dilate the vein and lead to dislodgement and migration of the device. Because blood tends to flow in both directions in a vein afflicted by venous reflux disease, this vein dilation effect would inevitably occur in a class of patients who can benefit greatly from vein occlusion.

If positioned in a vein ostium (i.e. with the cone/taper projecting into the "branch" vein lumen and the flange abutting the wall of the "main" vein at the junction), the Devellian device would be quickly ejected from the ostium by blood flow, as the physiological blood flow in the

venous system proceeds from smaller branch veins into larger main veins. (Again, bi-directional blood flow would be observed in refluxing veins, with the same result.)

For at least these reasons, there is little reason to expect that one could successfully position the Devellian device in a vein, and therefore one of ordinary skill in the art would not attempt to do so.

Devellian Reference - Claims 37 and 29

The Examiner rejected Claim 37, alleging it was anticipated by the Devellian reference. The Examiner also rejected Claim 29, alleging obviousness in light of the Devellian and Duran references. These rejections are incorrect for at least the reason that Claim 37 recites a "side wall being substantially conformable to a vein wall," and Claim 29 recites "a non-filtering, continuous side wall defining the lumen of the body and substantially conformable to the wall of the vein...." These rejections are incorrect because the Devellian cone cannot conform to the more-or-less cylindrical shape of a vein lumen, or to any portion of a vein that does not taper at precisely the same angle as the cone.

Moreover, Devellian's own disclosure lacks any teaching of conformance to the LAA. As seen in Fig. 4, there is only intermittent contact between the device 30 and the LAA – indeed, from inspection of Fig. 4, fully 4/5, or 80%, of the length of the device 30 has no contact with the LAA. Likewise, in Fig. 2B, the liner 21 is depicted as being out of contact with the LAA along most of its length.

Devellian's device would have even less contact in a vein. At most, the flange and a small portion of the cone/taper would abut the vein wall, with the bulk of the device out of contact with the vein.

In addition, one skilled in the art would not seek to turn the Devellian device into one that would have a "side wall being substantially conformable to a vein wall" as recited by Claim 37 or "a non-filtering, continuous side wall defining the lumen of the body and substantially conformable to the wall of the vein..." as recited in Claim 29. Devellian's liner and anchor are shaped in the disclosed tapered, conical manner to achieve Devellian's emphatically stated purposes of remodeling and decreasing the volume of the LAA (See Devellian, ABSTRACT, paragraphs [0011], [0027]). If the Devellian device did in fact conform to the LAA there would be little decrease in volume of the LAA, defeating these important purposes. The flange is also

critical for the proper functioning of the Devellian device. Whether implemented as a small flange as in Figure 2B or a more pronounced flange as in Figure 4, the flange is necessary to prevent the device from falling into the LAA. To modify the Devellian device to make it conformable to the LAA or to a vein wall (such as by changing its shape or removing the flange) would defeat the purposes emphasized by Devellian. Therefore such modifications of Devellian cannot be considered obvious. See M.P.E.P. § 2143.01 V, emphasizing that a proposed modification cannot render the prior art unsatisfactory for its intended purpose.

In view of the foregoing, Applicants respectfully submit that the rejections of Claims 37 and 29 over Devellian should be reconsidered and withdrawn. As to Claim 37, Devellian does not teach or suggest all of the recited limitations and Devellian therefore does not anticipate the claim. Claim 29, rejected as obvious over Devellian in view of Duran, is believed to be allowable as the cited references, even if combined, do not collectively teach or suggest all of the claimed limitations.

Dependent Claims

Numerous dependent claims remain pending but rejected over the prior art. Applicant respectfully submits that the pending dependent claims are also in condition for allowance, due to their dependence from allowable based claims as well as their recitation of further novel and non-obvious combinations of features.

Conclusion

For the foregoing reasons, it is respectfully submitted that the rejections set forth in the outstanding Office Action are inapplicable to the present claims. Accordingly, issuance of a Notice of Allowance is most earnestly solicited.

Applicant respectfully traverses each of the Examiner's rejections and each of the Examiner's assertions regarding what the prior art shows or teaches. Although the present communication may include alterations to the claims, or characterizations of claim scope or referenced art, the Applicants are not conceding in this application that previously pending claims are not patentable over the cited references. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application. The Applicants reserve the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including any subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child or related prosecution history should not infer that the Applicants have made any disclaimers or disavowals of any subject matter supported by the present application. Moreover, any arguments in support of patentability and based on a portion of a claim should not be taken as founding patentability solely on the portion in question; rather, it is the combination of features or acts recited in a claim which distinguishes it over the prior art.

The undersigned has made a good faith effort to respond to all of the rejections in the case and to place the claims in condition for immediate allowance. Nevertheless, if any undeveloped issues remain or if any issues require clarification, the Examiner is respectfully requested to call Applicant's attorney, David G. Jankowski, at (949) 721-6334 to resolve such issue(s) promptly.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: November 1, 2007

By: _____

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Abbott Announces Positive Six-Month Results From the World's First,Clinical Trial of a Fully Bioabsorbable Drug-Eluting Coronary Stent

[Outline]

Abbott's Bioabsorbable Stent Technology Holds Promise as Future-Generation Treatment Option for Physicians Treating Patients with Coronary Artery Disease

ABBOTT PARK, Ill., March 24, 2007 /PRNewswire-FirstCall/ -- Abbott today announced positive results from ABSORB, the world's first clinical trial evaluating the overall safety and performance of a fully bioabsorbable drug-eluting stent platform for the treatment of coronary artery disease. Six- month results from the first 30 patients in the trial, presented at the 56th Annual of Cardiology Scientific Session in New Orleans, demonstrated no stent thrombosis and a low (3.3 percent) hierarchical rate of ischemia-driven Major Adverse Cardiac Events (MACE), such as heart attack or repeat intervention.

"The encouraging results from the first 30 patients of ABSORB suggest that drug-eluting bioabsorbable stent technologies may be a promising future therapy option for physicians treating patients with heart disease," said Patrick W. Serruys, M.D., Ph.D., professor of interventional cardiology at the Thoraxcentre, Erasmus University Hospital, Rotterdam, who is co-principal investigator of the study. "A drug eluting stent that would eventually disappear after restoring blood flow is an exciting concept that we look forward to further exploring."

The single MACE event reported was a non-Q-wave myocardial infarction. The same patient underwent a repeat intervention that occurred at the site of the original procedure, resulting in an overall target lesion revascularization rate of 3.3 percent. The trial results confirmed that the treatment effect of everolimus in the bioabsorbable stent is similar to that observed in Abbott's studies of metallic drug-eluting stents, with everolimus actively inhibiting tissue growth into the artery. The rate of device success (successful placement of the bioabsorbable stent at the site of the lesion) was 93.5 percent.

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Related medicine technology :

1. Three Studies Suggest Abbotts Humira (adalimumab) May Improve Work Productivity

Abbott Announces Positive Six-Month Results From the World's First,Clinical Trial of a Fully Bioabsorbable Drug-Eluting Coronary Stent

[Outline]

Abbott's everolimus-eluting bioabsorbable stent is made of polylactic acid, a proven biocompatible material that is commonly used in medical implants such as dissolvable sutures. As with a metallic stent, the bioabsorbable stent is designed to restore blood flow by propping the vessel open, providing support until the blood vessel heals. Unlike a metallic stent, a bioabsorbable stent is designed to be slowly metabolized by the body and completely absorbed over time.

"Based on these encouraging safety results, Abbott will continue to advance this technology by enrolling the next cohort of patients in the ABSORB study in Europe and New Zealand," said John M. Capek, Ph.D., senior vice president, Abbott Vascular. "The next phase of the ABSORB study will utilize a next-generation bioabsorbable everolimus-eluting stent that incorporates several advancements designed to improve strength and deliverability."

About the ABSORB Trial

The ABSORB trial is a prospective, non-randomized (open label) study designed to enroll up to 60 patients in Belgium, Denmark, France, New Zealand, Poland and The Netherlands. Key endpoints of the study include assessments of safety -- MACE and stent thrombosis (blood clot formation) rates -- at 30, 180 and 270 days, with an annual follow-up for up to five years, and successful deployment of the bioabsorbable drug-eluting stent. Other key endpoints of the study include follow-up measurements assessed by angiography, IVUS, and state- of-the-art imaging modalities at 180 days and two years, as well as a new noninvasive technique in a subset of patients at 18 months. The co-principal investigator of the study is John Ormiston, M.D., of Mercy Hospital in Auckland, New Zealand.

For images of Abbott's bioabsorbable stent and other information, please visit the company's online ACC newsroom at http://www.abbottvascular.com/ACCpresskit .

About Abbot

Related medicine technology :

Abbott Announces Positive Six-Month Results From the World's First,Clinical Trial of a Fully Bioabsorbable Drug-Eluting Coronary Stent

[Outline]

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Abbott is a global, broad-based health care company devoted to the discovery, development, manufacture and marketing of pharmaceuticals and medical products, including nutritionals, devices and diagnostics. The company employs 65,000 people and markets its products in more than 130 countries.

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Nonmetallic Fixation in Elective Maxillofacial Surgery

AORN Journal, Jan, 2000 by W. Abernathy, M. McDANIEL, R. Edwards, K. Kiely, D. Frazier

Resorbable fixation has been investigated and documented for use in maxillofacial surgery since the early 1970s.(1) The first method that was approved by the US Food and Drug Administration in 1996 for clinical use in the United States was a copolymer of polylactic acid and polyglycolic acid. The advantages of using this resorbable technology include

* easily cut and shaped plates due to its malleable characteristics,

* strong and predictable resorption qualities, and

* improved patient acceptance and expectations. The application of absorbable plating is still in its infancy and can best be compared to the introduction of titanium plates as an alternative to wire osteosynthesis in the mid-1970s.

In the past, the use of metal fixation devices has led to several complications, the major one being the potential need for implant removal at some point in the patient's life. Other problems with metallic fixation devices are screw and plate migration, growth restriction, radiographic obstruction, and subsequent imaging distortion.(2) Furthermore, some investigations have shown that titanium implanted in the body sheds particulate matter into surrounding tissues and remote organs.(3) These complications have created the need for an improved, nonmetallic fixation material.

RESORBABLE TECHNOLOGY

The materials used for the bioabsorbable implants undergo hydrolysis. Water diminishes the integrity of the implants over time; therefore, hydrolysis makes the implants more bioabsorbable. Specialized cells known as macrophages rid the body of the implants as carbon dioxide and water reenter the normal physiological mechanisms at the cellular level via the Krebs cycle. Bioabsorbable plates and screws are completely reabsorbed into the body within 12 to 15 months with no sign of being implanted. Absorbable implants have proven to be nonpyogenic, nontoxic, nonmutagenic, and nonirritating.

These devices can retain up to 70% of their initial strength for up to eight weeks postoperatively. The eight-week period allows for osseous union in the maxillofacial skeleton, after which the implants never have to be removed. At 12 months, the body's natural metabolism evacuates the copolymer from the surrounding tissue by forming carbon dioxide and water, and by 15 months, the copolymer is completely eliminated.(4)

INDICATIONS FOR SURGERY

Resorbable technology can be used in most skeletal fixation procedures; however, most studies focus on craniomaxillofacial repairs. Research in resorbable science has been well documented in American, European, and Asian literature since the 1970s.(5) Indications for use in maxillofacial surgery are

* comminuted fractures of the nasoethmoidal and infraorbital areas,

* comminuted fractures of the frontal sinus well,

* trauma of the midface or craniofacial skeleton,

* reconstructive procedures of the midface or craniofacial skeleton, or

* orthognathic surgery.

This article describes experiences using resorbable fixation in orthognathic surgery (ie, procedures that correct malposition of the jaw bones). These procedures include Le Fort I osteotomies (ie, surgical disarticulation of the maxilla for repositioning), bilateral sagittal split osteotomy (ie, splitting of the lower jaw for advancement or setback of the mandible and genioplasties (ie, horizontal osteotomy of the chin for repositioning). In maxillary procedures, the fixation is performed with resorbable material or L-shaped plates secured with four resorbable screws per plate (Figure 1). Candidates for fixation typically are patients who complain of malocclusion, a condition in which the teeth do not close properly, causing problems with masticating.

[Figure 1 ILLUSTRATION OMITTED]

PREOPERATIVE CARE

Before the day of surgery, the surgeon completes a history and physical examination. The patient is made aware of the need for laboratory tests (ie, chest x-rays, blood tests), depending on the results of the physical examination. Preoperative tests include complete blood count, urinalysis, and preparation for autologous donation if needed. Autologous blood is rarely necessary as blood loss typically is 100 mL to 250 mL. The patient's mental status is evaluated to determine compliance with nutritional intake due to the required soft food postoperative diet.

The surgeon evaluates the patient's bony structures for prosthesis space and the size and shape of the alveolar structure. The surgeon also evaluates the patient's

* complaints related to prosthetics being used and the patient's reasons for wanting fixation,

* ability and willingness to cooperate with the treatment and subsequent personal care and oral hygiene, and

* general health and his or her medical or surgical risk.

Contraindications for fixation include

* infirm older patients;

* patients who have medical or surgical risks, such as uncontrolled diabetes, immunocompromised blood dyscrasia, or impaired cardiovascular function;

* patients who smoke or have drug or alcohol dependence;

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Nonmetallic Fixation in Elective Maxillofacial Surgery

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* patients who have psychiatric disorders; or

* patients who have had recent irradiation of the oral or facial tissues.

The perioperative nurse educates the patient about the surgical procedure, postoperative care, and anticipated outcomes. It is important for the nurse to assess the patient's responses and ensure that he or she understands his or her responsibilities. The patient will require a soft (ie, blenderized) diet for six weeks postoperatively. The patient also needs to understand how to use Yankauer suction while in the hospital to remove expected oral secretions and bloody drainage that will contribute to nausea if swallowed. It is appropriate for the nurse to educate the patient about adequate oral hygiene and the importance of having utensils at home to prepare food (eg, blender, strainer) after surgery. The patient also is instructed not to blow his or her nose for up to six weeks postoperatively.

The night before surgery, the anesthesia care provider assesses the patient for tolerance to anesthesia and difficulties that might be encountered during the procedure. At this time, the patient is informed of the preoperative NPO status.

On the day of surgery, the perioperative nurse sees the patient in the preoperative holding area. The nurse interviews the patient and completes a preoperative assessment, including verifying NPO status, presence of allergies, current medications, and health conditions. The circulating nurse develops a care plan and identifies a patient-related nursing diagnosis, including

* risk of latex allergy response,

* ineffective airway clearance,

* ineffective breathing patterns,

* risk of injury related to use of chemical agents or retained foreign objects,

* risk of perioperative positioning injury,

* risk of infection, and

* risk of fluid volume deficit.

The nurse reviews the consent form for accuracy and verifies all information with the perioperative nursing record and the patient. While the patient is in the preoperative holding area, the anesthesia care provider inserts the IV line and administers antibiotics to prevent infection before the patient is transported to the OR. If the patient exhibits anxiety, medications for sedation also can be administered after the consent is signed.

INTRAOPERATIVE PATIENT CARE

After being transferred to the OR, the patient is moved to the OR bed and positioned supine. The anesthesia care provider administers general anesthetic and intubates the patient with an endonasal tube. The patient's eyes are taped closed. The circulating nurse places a head drape around the patient's head, covering both ears. The drape overlaps at the forehead

and is secured with wide silk tape. The nurse turns the OR bed to a 45-degree angle and pads and secures the patient's elbows at his or her sides. The surgeon injects local anesthetic (ie, 2% lidocaine with epinephrine 1:100,000) for hemostasis and places a throat pack to prevent surgical debris from entering the hypopharynx. The circulating nurse completes the surgical prep. The mouth is cleansed with a semimoist scrub pad. The nurse preps the face and neck circumorally to the neck, preventing solutions from saturating the throat pack when prepping the mouth or from running under the tape on the eyes.

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Nonmetallic Fixation in Elective Maxillofacial Surgery

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The electrosurgical dispersive pad is placed on the patient, and the unit settings are verified. The surgeon and scrub person apply surgical drapes and position the suction, drill, and electrosurgical pencil on the field to be connected.

The circulating nurse has a heat pack readily available or delivers it to the sterile field. The scrub person then activates the calcium chloride heat pack with 120 mL of sterile water at least 20 minutes before use (Figure 2). The pack reaches a temperature of 55 [degrees] F (12.7 [degrees] C).

[Figure 2 ILLUSTRATION OMITTED]

Wearing a headlight to enhance vision, the surgeon makes skin and bone incisions to prepare the site. When the L-plates are ready, they are placed on the heat pack until they become malleable (ie, approximately 30 to 60 seconds). The L-plates then are adapted to the osteotomy incisions, using digital pressure to manipulate the plate to fit the patient's anatomy. The surgeon has approximately six to 10 seconds to configure the L-plates to accommodate the anatomy. After the L-plates are shaped, they remain on the back table until use.

The surgeon prepares the screw holes with the appropriate-size drill bit. The surgeon then taps the holes to accommodate the resorbable self-shearing hex-headed screws (Figure 3). The distal head driver--which is employed only with the bioresorbable system--is used on occasion to seat a prematurely sheared screw head or to remove a screw if needed.

[Figure 3 ILLUSTRATION OMITTED]

After the procedure is completed, the surgeon rinses and suctions the mouth thoroughly to remove all blood and debris and closes the intraoral wound before removing the throat pack. After extubation and transfer to the patient's bed, the patient's head is elevated to a 30-degree angle. The circulating nurse covers the patient with a warm blanket and transfers him or her to the postanesthesia care unit (PACU). Both L-plates and resorbable screws should be documented as implants.

POSTOPERATIVE CARE

Airway management is the most significant nursing concern for patients undergoing oral surgical procedures. The nurse must continually assess for evidence of acute airway obstruction due to edema. Pulse oximetry is monitored to detect the occurrence of hypoxia related to partial airway obstruction. The head of the patient's bed remains elevated at a 30-degree angle to promote airway patency. Patients typically present in the PACU with facial edema and require ice applications to the surgical site. The nurse should be alert to the need for frequent oral and lip care. To handle oral secretions, the patient is encouraged to rinse with small amounts of water via a 10 mL prefilled syringe and remove the water with the Yankauer suction. Although patients will have received teaching on the use of suction equipment, they might require assistance until they are fully alert. The patient may have areas of paresthesia related to the surgical site, which commonly diminish within one to two hours postoperatively.

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Nonmetallic Fixation in Elective Maxillofacial Surgery

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Shortly after discharge from the PACU, the patient will have radiographs taken to confirm the surgical correction. Implants are not visible on radiographs. The surgeon will determine follow-up plans on a case-by-case basis.

Patients having resorbable implants do not generally experience severe complaints of pain or require assistance suctioning after they are fully alert. Pain and antiemetic regimens can be implemented if needed and typically are effective to maintain comfort. To further promote comfort, a bedside humidifier can be used. In addition, removing dried blood by wiping it from the nasal passages is effective.

COMPLICATIONS

The postoperative assessment includes monitoring the patient for cyanosis, impaired respiratory functions, or other signs of airway compromise and inspecting the surgical site for signs of cyanotic or ischemic tissue. Hemorrhage also is a concern, although nosebleeds are fairly common. If bleeding is persistent after packing the nose or pinching the nose for several minutes, the surgeon should be contacted to further evaluate the patient. Low-grade fever is an expected occurrence during the first 24 hours postoperatively. A temperature greater than 101.5 [degrees] F (38.6 [degrees] C) warrants notifying the surgeon. Atelectasis is a common cause of fever during the first 24 hours postoperatively.

DISCHARGE INSTRUCTIONS

Foremost, the patient must be instructed to avoid blowing his or her nose, which can predispose the patient to trauma and infections from sinus pathogens. The nurse should teach the patient to continue performing oral rinses and frequent oral hygiene using a soft, angled toothbrush. High-pressure water oral hygiene devices are beneficial but should be used at a low setting after the first four to five days to avoid injury to the wound. The patient also will benefit from a dietary guide for preparing blenderized or pureed foods. It is beneficial for the patient's family members to be present for discharge instructions to help with the patient's continued recuperative needs. The patient may be instructed to eliminate activities that create negative pressure in the mouth caused by suction when smoking or drinking through a straw to minimize bleeding. He or she might also be instructed to eliminate strenuous exercise that might increase circulation and bleeding.

SUMMARY

Bioabsorbable technology is a revolution that has set new standards in maxillofacial surgery. Until now, when using metal plates and screws for fixation, screws often would migrate, creating the need for subsequent procedures. With the use of bioresorbable screws and plates, implants themselves completely reabsorb into the body via hydrolysis within 12 to 15 months. The technology has changed the standard of care and is the future of craniomaxillofacial fixation for adult and pediatric patients. Furthermore, bioresorbable technology is advancing other specialties, including orthopedics, cranial surgery, and plastic surgery.

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Nonmetallic Fixation in Elective Maxillofacial Surgery

AORN Journal, Jan, 2000 by W. Abernathy, M. McDANIEL, R. Edwards, K. Kiely, D. Frazier

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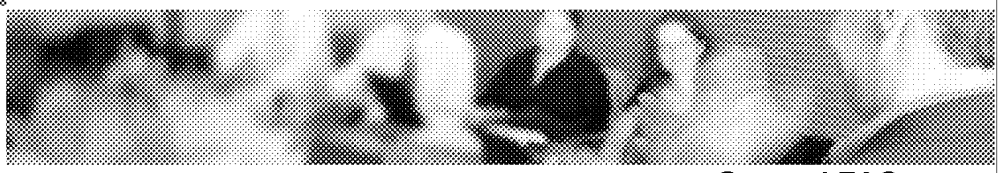


General FAQ

What are the Inion® products made of ?

They are made of a blend of rigid and elastic polymers selected for their strength, malleability and degradation properties.

By tailoring the polymer selections, fabrication processes and product designs each implant has optimal strength, malleability and absorption profiles to meet their specific clinical requirements.

The polymers in the Inion Optima™ materials are: L-Lactide, D,L-lactide, Trimethylene carbonate(TMC).The presence of TMC has a strong impact on the malleability (flexibility) of the final products and contributes to the product's ease of use by surgeons.

What are bioabsorbable polymers ?

Bioabsorbable polymers are a special class of plastic materials that allow the material to serve a function, and then gradually break down, metabolise and be eliminated from the body.

It is imperative to match the degradation time with the initial period during which the material must function.

The ideal bioabsorbable material will provide appropriate strength while degrading in a predictable fashion without adverse reactions occurring in the body throughout the healing process.

Specific Bioabsorbable Polymers ?

There are three main types of bioabsorbable polymers used in orthopaedics:

1. PGA: although highly crystalline, PGA absorbs very quickly into the body, losing virtually all strength within 1 month and all mass within about 6 to 12 months. During this phase of rapid absorption, large quantities of a glycolic acid monomer are released, potentially causing clinical complications within a few months following implantation.
2. PLLA: Poly (L) Lactic Acid has a much slower rate of absorption than PGA. The L (Levo) version of this polymer is highly crystalline due to the ordered pattern of the monomers, (i.e. L-L-L-L-L- L-L) and has been documented to take as much as 5-7 years to absorb.
3. PDLA: the D (Dexo) Isomeric form of PLA, has a much faster absorption rate.

What are the advantages of Bioabsorbable over Metal implants ?

Bio-absorbable implants have many advantages over metal implants, including:

1. Load sharing versus stress shielding
2. Eliminates the problem of leaving a permanent (metal) non-biologic implant in the body
3. Reduced risk of articular damage (refer to case study below)
4. MRI compatible for Post-Op diagnosis
5. Reduce radiographic scatter
6. Minimised risk of obstruction during revision surgery if required
7. Safe and biocompatible material, no risk of metal allergic reactions
8. Minimised risk of stress risers normally associated with implant removal.
9. As with all bioabsorbable implants, they biologically resorb over time, allowing the load to transfer to the bone after primary bone healing and eventually completely disappear through safe biological resorbtion.
10. Bioabsorbable polymers are a special class of plastic materials that allow the material to serve a function, and then gradually break down, metabolise and be eliminated from the body. Thus eliminating the need for metal implants to me used during surgery.

What is the difference between bio-resorbable, bio-degradable and bio-absorbable implants?

By scientific definition, biodegradable refers to a biological mediated degradation process such as enzymatic and/or cellular processes. Bioresorption refers to a chemically mediated degradation process such as hydrolysis where the degradation products are then

incorporated into normal metabolic pathways like the Krebs Cycle. Bioasbsorbable also refers to a chemically mediated degradation, but the degradation products are generally excreted through one of the body's organ systems. All three terms are unfortunately used indiscriminately in both scientific and clinical literature and this has caused significant confusion. The above definitions are of course too much for this Q/A info sheet. Perhaps the best answer is to say the terms are in general the same in the sense that degradation occurs in the human body, but there differences are related to the degradation process. Then mention the indiscriminate use of the terms in the literature and suggest that Inion has chosen the term "bioabsorbable" for materials that breakdown in the human body

What is Inion Optima™ ?

Inion Optima™ materials are made by the blending of rigid polymer components and elastic polymer components. The resulting polymer blends possess extraordinary combination of strength, toughness (malleability) and degradation profile.

Why have you used TMC in some of the Inion® implants?

The presence of TMC (Trimethylene Carbonate) has a strong impact on the malleability (flexibility) of the final products and contributes to the product's ease of use in the surgical environment. Copolymers using trimethylene carbonate as a minor component have been on the market since the 1980s as sutures and guided tissue membranes, and more recently as sports medicine implants

Have there been any problems with patients who have received bio-absorbable implants?

Most problems that have been reported in printed publications were thought to be due to the fast degradation of polymers and possibly particulates from semi-crystalline materials. Inion Optima Materials used in all of the implants and have been tailored to degrade gradually in each application. In addition Inion materials are completely or substantially amorphous, even after processing, and therefore are not crystalline or semi crystalline.

What are the resorbtion times of the Inion® bio-absorbable implants?

The time frame is usually between 35 weeks and 3 years but this varies from patient to patient. Also resorption is also dependant on a number of other factors including:

implant mass

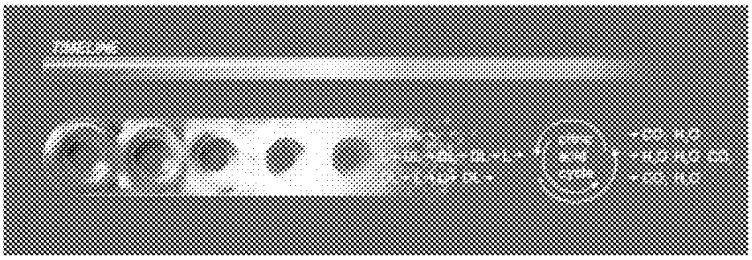
material processing

implantation area, e.g. vascularity

The implants initially lose molecular weight, then strength and finally mass.

What eventually happens to the implant?

The implants degrade by hydrolysis and over a period of time are metabolized into carbon dioxide and water which is then exhaled and excreted.



What happens to the polymer crystals and can they cause cancer?

Inion Optima™ materials are both safe and biocompatible with the human body. They are completely or substantially amorphous – the ideal for biodegradable implants.

Crystalline polymers have a regular internal structure and because of the orderly arrangement are slow to degrade. Amorphous polymers have a random structure and are completely & more easily degraded. Semi-crystalline polymers have crystalline and amorphous (random structure) regions. Hydrolysis begins from the amorphous area leaving the more slowly degrading crystalline debris. These crystalline regions (crystals) are extremely small.

Can you re-sterilize the implants if they have been opened but not used?

Absolutely not. All Inion® implants are packaged as single use only. This prevents the potential cross infection risk and alleviates problems of decontamination.

Are bio-absorbable implants radio opaque?

No. The screw holes can be seen in post operative X-rays

Can you use Inion bio-absorbable products in patients who are lactose intolerant?

Lactose is a natural sugar found in most mammalian milk. The chemical structure of lactose is very different from that of lactic acid which is a natural metabolite of carbohydrate metabolism. One would not expect any interaction all from lactic acid on lactose intolerant people. There is a much higher risk for patient allergies to metal implants due to beryllium and copper additives.

How should bio-absorbable products be handled and stored?

It is quite common for Sales Representatives to store bio-absorbable products in the trunk or interior of their car. This practice can cause serious product performance issues with bio-absorbable products. The nature of the material and the process of production does not protect it from the temperatures within a car or trunk during the summer months, many near the temperature seen in production. This may cause a warpeage in the implant and thus cause deployment and insertion issues. To prevent this, no bio-absorbable product or otherwise should ever be continually left in a car interior or trunk

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Adjunctive Therapy: Biodegradable Stents: They Do Their Job and Disappear

- **Ron Waksman, MD**

Despite the development and progression of metallic stents, many concerns still remain because of their permanent nature. Although metallic stents are effective in preventing recoil and late restenosis after coronary angioplasty, they continue to have limitations such as stent thrombosis and mismatch of the stent to the vessel size. Thus, the concept of bioabsorbable stents has emerged as an alternative to permanent metal stents. This review will outline concepts, material designs, preclinical, and initial clinical experimental studies with bioabsorbable stents.

Coronary stenting has become the default device in percutaneous coronary interventions (PCIs). Coronary stents are used as a mechanical means to overcome the major limitations of balloon angioplasty with enabling scaffolding and the prevention of early recoil and late vascular remodeling.[1–3] The major limitations of stents are thrombosis and restenosis. While thrombosis has been controlled with the use of antiplatelet therapy, restenosis has been significantly reduced with the use of drug-eluting stents. Nevertheless, the role of stenting is temporary and is limited to the intervention and shortly thereafter, until healing and reendothelialization is obtained. Beyond that, no utility or advantage for stents has been demonstrated and their presence could be a nidus for late thrombosis and chronic inflammation.

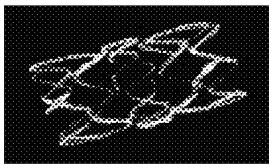
Why bioabsorbable stents?

Problems with metallic stents solved by bioabsorbable stents. Despite the development and progression of metallic stents, they continue to have limitations such as stent thrombosis, which requires prolonged antiplatelet therapy, and mismatch of the stent to the vessel size, which often results in a smaller lumen after stent implantation. Further, metallic stents prevent the lumen expansion associated with late favorable remodeling.[4]

Permanent metallic stents **Figure 1**

Peripheral Interventions
Primary Angioplasty
Stenting
Stroke
Valvuloplasty
Vein Graft Intervention

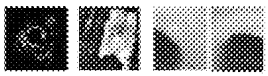
impair the vessel geometry and often jail and obstruct side branches. Drug-eluting stents are a breakthrough in the development of stents, with their ability to significantly reduce restenosis rates and the need for repeat revascularization.



Design of Igaki-Tamai stent and its magnesium alloy.

Nevertheless, they are still associated with subacute and late thrombosis, and necessitate prolonged antiplatelet therapy for at least 12 months. Further, the polymer used as a vehicle for drug delivery may induce vessel irritation, endothelial dysfunction, vessel hypersensitivity and chronic inflammation at the stent site.[5] Excessive use of stents in the coronary vasculature (full metal jacket) may interfere with traditional reinterventional techniques such as bypass graft surgery. Finally, metallic stents pose artifacts with modern imaging technologies such as magnetic resonance imaging (MRI) and multislice computerized tomography (MSCT), which eventually will become the default noninvasive imaging modality for the coronary anatomy.

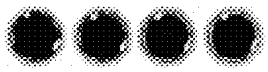
Figure 2 Top



Steps in bioabsorption of the magnesium stent.

In contrast, bioabsorbable stents, once they are bioabsorbed, leave behind only the healed natural vessel, allowing restoration of vasoreactivity with the potential of vessel remodeling. Late stent thrombosis is unlikely since the stent is gone, and prolonged antiplatelet therapy is not necessary in this instance. Bioabsorbable stents can also be suitable for complex anatomy where stents impede on vessel geometry and morphology and are prone to crushing and fractures, such as is seen in saphenous femoral and tibial arteries.

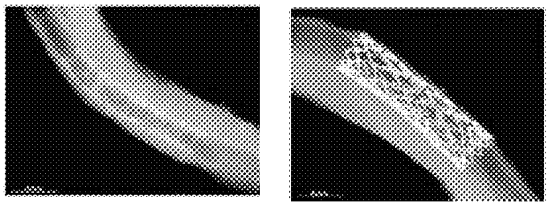
Figure 2 Bottom



Bioabsorbable implant stents can be used as a delivery device for agents such as drugs and genes, and will perhaps play a role in the treatment of vulnerable plaque. Transferring genes that code key regulatory pathways of cell proliferation inside the cells of the arterial wall using polymer stents as vehicles is feasible. Regardless of which agent (drug or gene) will finally conquer restenosis, a polymer stent remains an optional vehicle for such delivery. Finally, bioabsorbable stents are compatible with MRI and MSCT imaging.

Polymer stents for local drug and gene delivery. Polymeric stents have the potential to act as local drug delivery systems. Polymeric material, especially biodegradable polymers, have been widely utilized for the controlled release of drugs,[6–9] Therefore, it is possible to design a biodegradable

Figure 3 Top Left **Figure 3 Top Right**

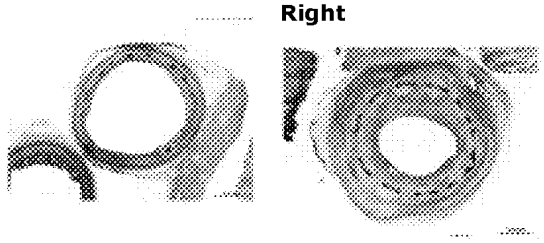


Magnesium versus stainless steel stent approximately 30 days after implantation in porcine coronaries.

polymer stent, not only offering a physical barrier to the vessel wall, but also presenting a pharmacological approach in the prevention of thrombus formation and intimal proliferation. These bioabsorbable polymers are currently loaded on the metallic stent for the purpose of drug or gene delivery, and completely erode by the time the drug has been released; yet the stent itself is still maintained in the vessel wall. The discussion of these bioabsorbable polymers is beyond the scope of this review, however.

Bioabsorbable polymers and stent designs. There are several conditions to consider when selecting a polymer or alloy for the bioabsorbable stent. These include the strength of the polymer to avoid potential immediate recoil, the rate of degradation and corrosion, biocompatibility with the vessel wall and lack of toxicity. The change in the mechanical properties and the release profiles of drugs from bioabsorbable stents would directly depend on the rate of degradation of the stent, which can be controlled by selection of the stent alloy, passivation agents and the manufacturing process of the stent. Currently there are two types of materials used for bioabsorbable stents: polymeric-based and metallic-based.

Figure 3 Bottom Left **Figure 3 Bottom Right**



Polymers have been widely used in cardiovascular devices and are currently primarily used as delivery vehicles for drug coatings.[10,11] Among the polymers suggested for bioabsorbable stents are Poly-L-lactic acid (PLLA), polyglycolic acid (PGA), poly (D, L-lactide/glycolide) copolymer (PDLA), and polycaprolactone (PCL). The degradation rates of these polymers are listed in Table 1. Each of these polymers was designed as either self-expanding or balloon-expandable stents. Another proposed design is the hybrid stent, which combines polymeric absorbable stents with a metallic backbone to enable strength and prevent recoil.

Among the first polymeric stents to be tested

was the PLLA bioabsorbable stent designed and tested by Stack et al.[12] and is reported to hold up to 1,000 mmHg crush pressure and maintain its radial strength for 1 month. This stent was almost completely degraded by 9 months with minimal thrombosis, moderate neointimal growth and a limited inflammatory response in porcine coronary arteries. The Igaki-Tamai stent, another polymeric stent, is made of poly-L-lactic acid monofilament (molecular mass = 183 kDa) with a zigzag helical coil design (Figure 1). Another interesting concept is the multilayered biodegradable stent designed by Eury et al.,[13] which is made of various polymers such as poly-L-lactic acid, polyglycolic acid, polycaprolactone, polyorthoesters or polyanhydrides. The unique feature of the stent is that one layer addresses the structural requirements of the stent and an additional layer controls the release of different drugs. The laminated construction allows the combination of a plurality of different drugs containing different materials all within a single stent. By appropriate configuration of the layers, drug release characteristics can be adjusted.

Preclinical studies with polymer stents. The initial experimental studies with biodegradable polymers using (poly D, L-lactide/ glycolide c-polymer), polycaprolactone, poly (hydroxybutyrate-hydroxyvalerate and polyorthoester) coated as films on the circumferential surface of coil wire stents in the porcine coronary arteries were disappointing. Thirty days postimplantation, histopathology revealed that all these coatings were associated with a significant inflammatory response and neointimal proliferation with extensive cell infiltration of multinucleated giant cells, leukocytes, lymphocytes, monocytes and eosinophils. In addition, there was evidence of medial necrosis and pseudoaneurysm formation.[14] Lincoff et al.[15] demonstrated that poly-L-lactic acid, with a low molecular mass, is associated with an intense inflammatory reaction, whereas a minimal inflammatory reaction occurs with high molecular mass poly-L-lactic acid.

The Igaki-Tamai stent was compared with a Palmaz-Schatz stent and showed no stent thrombosis and no significant differences in minimal lumen diameter at 6 months. Histological examination revealed no inflammation and minimal neointimal hyperplasia on poly-L-lactic acid stent struts.[16]

Using a stent made of copolymer L-and D-lactide (L/D ratio 96/4%), Hietala et al.[17] conducted a 34-month study in rabbits. This is the longest known study using a polymer stent, and reported complete endothelialization at 3 months with no inflammatory reaction observed after 6 months. Hydrolyzation of the stent was evident at 12 months and it was completely disintegrated by 24 months. The stent was gradually replaced by fibrosis. The vessel lumen remained patent at all time points. In contrast, the Kyoto University bioabsorbable stent made of polyglycolic acid and polyhydroxybutyrate stents was

associated with thrombosis and intensive inflammatory vascular reactions.

Preclinical studies with polymer stents for local drug delivery. Yamawaki et al.[8] incorporated an antiproliferative agent into the high-molecular weight poly-L-lactic acid Igaki-Tamai stent. Stents loaded with ST638 (tranilast, a specific tyrosine kinase inhibitor) or ST494 (an inactive metabolite of ST638) were implanted in porcine coronary arteries. Histological examination showed that the extent of neointimal formation and geometric remodeling were significantly less at the ST638-loaded stent site then at the ST494 site. Vogt et al.[9] used a paclitaxel-eluting poly (D, L)-lactic acid (PDLLA) and reported a slow-release profile of paclitaxel, with an exponential function starting with a daily release from 5–8 µg, which was decreased to 1 µg at 4 weeks and to 0 at 3 months. Overall, the stent demonstrated mechanical stability. The histomorphometric analysis at 3 weeks demonstrated inhibition of neointimal formation by 53% with the paclitaxel-loaded PDLLA when compared to the PDLLA stent, and by 44% when compared to the metal stents. This reduction was durable at 3 months. These studies demonstrated the feasibility of loading drugs on the biodegradable polymeric, which resulted in a reduction in neointimal formation.

Preclinical studies with polymer stents for local gene delivery. Ye et al.[18,19] demonstrated the successful transfer and expression of a nuclear localizing beta–Gal reporter gene in cells of the arterial walls in rabbits. They used a poly-L-lactic acid/poly-caprolactone blend stent impregnated with a recombinant adenovirus carrying the beta–Gal reporter gene.

Human experience with the polymer stent. Tamai et al.[20] were the first to report immediate and 6-month results after implanting the Igaki-Tamai stent in 15 patients. A total of 25 stents were electively and successfully implanted in 19 lesions, with angiographic successes in all procedures. The authors provide clinical and angiographic follow-up data at 1 day, 3 months and 6 months. No stent thrombosis or major cardiac event occurred at 30 days. Angiographically, both the restenosis rate and target lesion revascularization rate per lesion were 10.5%, while the rates per patient were 6.75% at 6 months. Even so, the presence of a loss index of 0.48 at 6 months is encouraging. The study showed that the Igaki-Tamai stent may not be associated with more pronounced intimal hyperplasia than stainless steel stents. Interestingly, there was evidence of vascular remodeling at the stented site, with an increase of the stent cross-sectional area from 7.42 mm^2 at baseline to 8.18 mm^2 at 3 months as evaluated by intravascular ultrasound. This persistent expansion was associated with a decrease in the lumen cross sectional area, although after the third month, no further stent expansion was observed. Tsugi et al.[21] reported 1-year follow-up data in a total of 63 lesions in 50 patients who underwent

elective stent implantation with the Igaki-Tamai stent. No complications with regard to stent implantation were reported. Quantitative coronary angiography at 3, 6 and 12 months demonstrated percent diameter stenoses of 12 ± 8, 38 ± 23, and 33 ± 23, respectively. Restenosis rates were 21% (12/58 lesions) at 6 months and 19% (7/36 lesions) at 12 months. The target lesion revascularization rate was 12% (7/58 lesions) at 6 months and 17% (6/36 lesions) at 12 months. A recent report of 4-year follow up on this cohort supported the long-term safety profile of the Igaki-Tamai stent. Further studies in the SFA with this stent demonstrated feasibility and safety in deployment of these stents over a length of 70 mm. Overall, these findings demonstrated feasibility and safety, with acceptable efficacy of the use of biodegradable poly-L lactic acid stents in human coronary arteries.

Limitations of the polymer stents. Polymeric biodegradable stents have demonstrated several limitations. Their strength is lower when compared to metallic stents, which can result in early recoil postimplantation. They are associated with a significant degree of local inflammation. The bioabsorption rate is relatively slow, and may still result in restenosis. These stents are radiolucent, which may impair accurate positioning. Furthermore, it is difficult to deploy the stent smoothly and precisely without fluoroscopic visualization. The polymer alone has a limited mechanical performance and a recoil rate of approximately 20%, which requires thick struts that impede their profile and delivery capabilities, especially in small vessels.[6,22]

Bioabsorbable metallic stents. Metal bioabsorbable stents are intuitively attractive since they have the potential to perform similarly to stainless steel metal stents. So far, two bioabsorbable metal alloys have been proposed for this application: iron and magnesium. The biocompatibility of these stents depends on their solubility and their released degradation products. Their local toxicity is related to the local concentration of the elements over time. The tissue tolerance for physiologically occurring metals depends on the change of their tissue concentrations induced by corrosion. Thus metals with high tissue concentrations are the ideal candidates for bioabsorption stents (Figure 2).

Preclinical studies with corrodible metallic stents. Peuster et al.[23] reported on experimental studies with absorbable iron stents. They implanted stents made of 41 mg (equal to the monthly oral intake of iron) of pure iron into the native descending aorta of New Zealand white rabbits. There were no thromboembolic complications or any other adverse events during the 6 to 18 months of follow up. In addition, there was neither pronounced neointimal proliferation nor significant inflammatory response.

Magnesium is considered an attractive alloy for bioabsorption. The stent underwent several design iterations to allow scaffolding and support during stent corrosion. Heublein et al.[24] conducted a series of in vitro and in vivo preclinical trials using stents

made of magnesium alloy. These studies demonstrated relatively high rates of degradation from 60 to 90 days, while the overall integrity of the stent remained at 28 days. In vivo studies supported stent integrity during corrosion and biocompatibility with endothelial cells and smooth muscle cells. A series of animal studies in which magnesium alloy stents were implanted in porcine coronary arteries demonstrated a reduction of neointimal formation when compared to the stainless steel stent 316 L, positive vessel remodeling at the stented site from 30 to 56 days, and complete absorption of the stent at 56 days. Animal studies carried out for up to 180 days demonstrated durability of the results at 56 days. In addition, there was no evidence of fibrin or thromboembolic events in the magnesium alloy implanted stents. Further studies showed a minimal degree of inflammation, but less when compared with L316 metallic stents (Figure 3).

Initial clinical trials with the Mg alloy absorbable stent. The first clinical trial to test the feasibility and safety of the magnesium bioabsorbable stent was performed in 20 patients who presented with claudication due to severe peripheral vascular disease (Rutherford Class IV and V), and who were candidates for amputation. These patients had lesions in the proximal two-thirds of one or more infrapopliteal arteries, and were subjected to PCI with the magnesium stent under a compassionate base protocol. Following predilatation, the 3.0 x 15 and 3.5 x 15 mm magnesium stents were successfully deployed with good angiographic and ultrasound results. There was no evidence of blood or vessel toxicity, and the patency rates at 3 and 6 months postimplantation were 89% and 78%, respectively. Limb salvage was obtained in all patients at 3 months, while at 6 months, 1 patient underwent amputation to the limb intervened upon. Duplex ultrasound and MRI demonstrated complete absorption of the stents at 3 months.

The results of this study have led to a clinical trial with the magnesium stent in coronary arteries. The PROGRESS study is designed as a safety study in 65 patients in 7 European centers. The intravascular ultrasound follow-up scheduled at 4 months will determine whether these stents are indeed disappearing and will indicate what the restenosis rate will be. The initial implantation of these stents in the coronary arteries was successful, with good apposition of the stent imaged by IVUS.

Currently, magnesium stents are not visible by X-ray and are not loaded with drugs for the prevention of restenosis. The need for such a drug will be determined by the results of the clinical trials since the recoil is minimized with the use of a metallic stent and the trigger for continuous inflammation is gone shortly after stent deployment. This stent will result in less restenosis than is seen with bare metal stents. If drugs are essential to control restenosis, they can be loaded with another bioabsorbable polymer or without an additional vehicle using the magnesium as the platform for those drugs.

Future directions. Though biodegradable polymer stents and biocorrodible metallic stents seem to be ultimate candidates for the ideal stent, further research is required before they can substitute the conventional bare metal or drug-eluting stent. If so, they may eliminate the need for prolonged antiplatelet therapy and will be compatible with future noninvasive imaging of the coronary tree.

By controlling the ideal absorption time and rate, they can be useful for other applications such as angiogenesis and gene transfer. Once they deposit the drug locally, the vehicle as a whole will disappear in the surrounding tissue. In the meantime, it would be interesting to follow whether the bioabsorbable stent concept will be adopted and thus eliminate the current practice in which many patients chronically carry metal prostheses in their coronary arteries.

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